Biogas: An opportunity fuel that will be increasingly used in the future

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Biogas is regularly produced at wastewater treatment plants, landfills, and food and other industrial operations throughout the world. In addition there is largely untapped potential in agricultural operations where animal waste (manure and processing waste) is often land applied or otherwise disposed of without conversion to energy. Technological, economic, and political changes are converging to encourage the use of this renewable resource for energy production. A careful review of these factors suggests that the use of this resource will increase.

Humans produce an average of 1 cubic foot of biogas per day. This gas is largely captured in municipal wastewater systems. Biogas becomes available for energy generation at wastewater treatment plants with anaerobic digesters. This gas, which is typically about 65 percent methane with heating values of about 650 million British thermal units (Btu) per cubic foot, is a by-product of the treatment process. Treatment plant operators focus on meeting water quality and biosolid disposal standards, not on generating gas for energy production. Consequently, much of the gas captured is flared, particularly at small and mid-sized wastewater treatment plants

Biogas is a potentially important energy resource. Technologies exist to convert it to energy, with limited impact on treatment plant operations and relatively little environmental impact. Various technologies, operating practices, environmental considerations, and financial incentives are reviewed to provide insight into the potential for expanded biogas use.

Landfills offer a much greater potential for energy production than digesters at wastewater treatment plants. The decomposition of organic material in landfills produces gas that is typically 50 to 60 percent methane. This gas often needs to be collected to reduce odors and avoid combustion and other associated hazards. Landfill biogas has many of the same attributes as digester gas although it is available in larger quantities and typically has a lower Btu value (600 Btu per cubic foot). A landfill that supports a population of 100,000 people could support about 5 megawatts of generation capacity. While more than 200 conversion systems are in place, this resource remains largely untapped. In some places the gas is collected and flared, and in others it is not even collected. The use of biogas can be expanded by improving gas collection activities at smaller landfills and by employing practices that increase gas production and the efficiency of the conversion to energy. Environmental impacts are an important consideration, but there are significant benefits, particularly related to greenhouse gas emissions, in collecting and using the gas for electricity generation. Several projects in the western United States are reviewed that show how biogas can be used.

Industrial and food processing operations frequently use biogas produced at their facilities for energy production. Waste disposal costs, the need for process energy, and environmental regulations contribute to the relatively high use of biogas. In contrast, animal waste at dairy and other cattle operations represents a potentially significant energy resource that generally is not converted to energy. With each cow producing approximately 12 pounds of manure a day (7,500 Btu/dry pound), cattle operations have the potential of producing up to 1 kilowatt of energy per cow per day. Much of this potential energy is lost through natural processes, and in collecting and managing the waste. With concentrations of cattle exceeding 100,000 at some dairy and feeding operations, the potential for energy recovery is significant.

Although the potential resource is significant, the economics of generating energy from animal waste are not as favorable as for digesters or landfill operations. The primary reason is that animal waste is land

applied, so there are significant additional costs associated with waste collection and treatment that need to be considered as part of an energy recovery project. Other drivers, such as environmental and groundwater standards, are becoming increasingly important. In highly agricultural areas, these requirements are imposing added costs on dairy operators. Installing energy recovery systems enables some of these costs to be offset, which is a factor that is likely to become increasingly important. These advantages are incorporated into the analysis of the feasibility of animal waste to energy facilities in Southern California's dairy region and in Oregon. Overall, animal waste to energy projects are technically feasible and environmentally sound, but are only economically viable if these ancillary considerations are taken into account.

Biogas has been managed in a variety of ways for several years, ranging in technical sophistication from disposing of the gas using flares to converting the gas to electricity using fuel cells. Each of the conversion processes listed in Table 1 below has advantages and disadvantages, which are addressed in the paper.

Table 1. Summary of Biogas Conversion Processes

Energy Conversion Technology	Advantages	Disadvantages
Biogas-fired Boilers	Straight-froward technology that reduces fuel costs particularly well suited in providing process heat to digesters	Applicability limited to digesters or other uses where process needs are significant
Biogas Direct Drive Equipment	Relatively efficient use of gas to provide energy	Limited flexibility. Cannot always match gas levels to energy requirements
Biogas Internal Combustion Engine Generator Sets	Widely used equipment with relatively low capital cost	Relatively high emissions. Equipment requires relatively high level of maintenance
Biogas-fired Turbines	Wide range of sizes above 1 megawatt available	Use on digester gas applications limited
Biogas-fired Microturbines	Low emissions can be applied to small facilities	Small size limits use to small facilities
Fuel Cells	Clean and efficient	Capital costs very high
Waste Heat Recovery Systems	Greatly improve efficiency, where applicable	Limited applicability to digesters and industrial operations where process heat requirements exist